Construction Protocol of Wireless Sensor Network Based on Centralized Clustering Routing and Time Division Multiplexing MAC Protocol

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Abstract

LEACH is a routing protocol based on clustering in wireless sensor networks and is based on a low power adaptive hierarchical routing algorithm design of wireless sensor network. Time division multiplexing mechanism is for each wireless sensor network node distribution independent time slots for data transceiver, and the node into sleep state in other free time slot. This paper introduces MAC protocol based on time division multiplexing. The paper proposes construction protocol of wireless sensor network based on centralized clustering routing and time division multiplexing MAC protocol. The simulation results show that the LEACHEE protocol can effectively reduce network energy consumption, prolong the network life cycle.

Keywords: wireless sensor network, time division multiplexing, centralized clustering routing

1. Introduction

In wireless sensor networks, medium access control (medium access control, MAC) protocols determine the usage mode of wireless channel, the underlying infrastructure to build sensor networks through the allocation of the limited resource of wireless communication between the sensor nodes. The bottom part of the MAC protocol in sensor network protocol, has a great effect on the performance of sensor networks, is the key to ensure the efficient communication network protocols in wireless sensor networks.

Wireless sensor networks (WSN) is deployed in the monitoring area by the large number of cheap micro sensor nodes, a self-organized network system through wireless communication to form, its purpose is to cooperative sensing, collecting and processing network information of object in the coverage area, and send it to the observer. Because the nodes of wireless sensor networks, energy storage, computing capacity and other constraints, the traditional wireless routing protocols are not suitable for wireless sensor networks [1]. Therefore, the design can effectively save energy, prolong the network life cycle routing protocol, is of great significance to wireless sensor network. The cluster based routing protocol has good performance in this aspect.

In wireless sensor networks, energy efficiency is an important index of network performance. It consumes a very strict limits on energy, should be as little as possible energy consumption to prolong the network life cycle to. Therefore, to design a good routing protocol, it is necessary to reduce unnecessary energy consumption. This paper mainly discusses the low energy adaptive clustering protocol (LEACH), points out the defects of LEACH protocol, and gives corresponding solution to be optimized.

Because of the wide use of miniaturized sensor nodes, node in the supply of energy, computing power and storage space and other hardware resources are very limited, the MAC protocol must be designed with energy saving as a prerequisite. For WMSN, the transmission and complex processing task, while providing QoS guarantee must consider how to efficient use of these resources, QoS sensitivity is an important feature of WMSN, embodied in the audio and video quality, network delay, energy consumption and network media information processing aspects of. WMSN compared with the traditional WSN, MAC protocol design need to pay attention to the quality of service more.

LEACH (Low Energy Adaptive Clustering Hierarchy) protocol is a routing protocol based on clustering in wireless sensor networks, by periodically elects cluster heads randomly to ensure that the nodes have equal chances to be the cluster head, balanced energy consumption of nodes, so as to achieve the purpose of extending the network life cycle. The clustering idea runs through a lot of cluster based routing protocol was proposed. The paper proposes construction protocol of wireless sensor network based on centralized clustering routing and time division multiplexing MAC protocol.

2. Research of LEACH Centralized Clustering Routing Protocol in WSN

Aiming at the defects of LEACH C protocol in wireless sensor networks, this paper presents a clustering routing protocol based on energy estimates based on LEACH C protocol. The agreement on the energy consumption is estimated, reducing the traffic sensor nodes and a base station, energy saving of the whole network.

WSN can be divided into two research directions of topology control: power control and hierarchical topology control. The transmit power of each node power control mechanism to adjust the network, to guarantee network connectivity, the number of direct neighbors in the equilibrium (up to a number of neighbors nodes in single hop) at the same time, to reduce the interference between nodes. Hierarchical topology control is the use of clustering, so that part of the nodes in the network is active, become the cluster head node [2]. The cluster head nodes construct a connected network to the transmission and processing of data in the network, and regularly or irregularly to select cluster head nodes, to balance the energy consumption of nodes. In WSN, the wireless communication module node in power transmission state supreme, receiving state and the idle state power of the dormant state, the lowest power consumption.

LEACH protocol is based on a low power adaptive hierarchical routing algorithm design of wireless sensor network, routing protocol is proposed first. Its basic idea is to the circulation of the random selection of cluster head nodes, other nodes cluster grouping according to the signal strength received from the cluster head, making the whole network energy load average assigned to each sensor node, thereby reducing the network energy consumption, improve the survival time of the entire network. The LEACH protocol defines the conception of "round", each round consists of a cluster is established and the steady state phase. In a cluster, the cluster head selection is random. For a node n, which were randomly selected from a random number between 0 to 1, if the number is less than a threshold value of T (n), node n as is the cluster head node to it.

If the cluster structure isomorphic clustering method, the cluster energy is often the distance from the base station near consumption must be relatively large, leading to a new round of cluster head election, causing the entire network to suspend work, even in the early stage of nodes into death. To avoid this situation, the preliminary algorithm using cluster size heterogeneous cluster structure, namely the distance from the base station is far than the distance between cluster structure base station near large, to balance the energy consumption of data forwarding.

During the deployment of network, the base station transmission power of a given network to broadcast a signal. Each sensor node receives the signal, according to the strength of the received signal to calculate it to approximate the distance from the base station. This distance, not only contribute to the sensor nodes transmit data to the base station when selecting the transmit power available to reduce the energy consumption, and it is still one of the size of the non uniform clustering algorithm to construct the information necessary.

This paper assumes that the N sensor nodes randomly distributed in the A region and the sensor network has the following characteristics:

(1) The network deployment is completed, all nodes are stationary, and the node can obtain the position information.

(2) The network scale is small; all nodes can communicate with the base station directly. The base station only is fixed position.

(3) The ordinary node energy is limited, and has the same computational, communication ability and initial energy, and energy and computing capability of base station without limit.

WSN nodes energy consumption model data as follows.

Sensor nodes transmit the consumption of R bit packet energy, is shown by Equation (1).

$$P_t (R, d) = r (a_1 + a_2 d_n) \tag{1}$$

Where: d is the distance between the two nodes; a_1 is independent of the distance, which comprises transmitting circuit energy consumption; a_2 is related to the distance of the weight; n is the path loss exponent, usually from 2 to 4.

The LEACH algorithm will load uniformly distributed throughout the network, greatly saves the energy loss in the process of communication. Rotation algorithm cluster head position to load remote communication in turn assigned to the network node, the whole system can prolong the survival time of. In addition, the cluster head node uses a data fusion and data compression technology in the processing of the data, the data transmission is greatly reduced.

In order to prolong the network life cycle, should try to choose the cluster node residual energy as cluster head node is the highest, and let the different node rotation was elected. This part adopts cluster head election method of residual energy of cluster head rotation based on cluster. The main idea: cluster head in the cluster is responsible for the collection of nodes in the cluster data. In the cluster head nodes to transmit data, the residual energy of the nodes in the data bits added value after a. The cluster head will data forwarding, each node of the energy of a simple sort, because no maintaining total ordering all the energy of the node, you only need to know a few node residual energy is high, so the maximum heap sort method.

LEACH is a typical adaptive clustering protocol, nodes in the network through the random way self organize into clusters, the cluster head sends data in time slots are assigned to the cluster head, the received data fusion in each frame after the end of direct communication with the base station [3]. Nodes in cluster head, balance the network energy consumption, but the cluster heads are elected, does not consider the node energy level, if the node energy is very low, still want to act as cluster head, it will accelerate the death. In addition, the data sent directly to the base station, the energy consumption of the nodes is far from base stations is very large, leading to local nodes die prematurely, the monitoring blind spot.

The radio energy consumption model is with the same reference. When data is transmitted energy consumption, as is shown by Equation (2).

$$E_{Tx}(k,d) = \begin{cases} kE_{elec} + k\varepsilon_{fs}d^2, & d < d_0 \\ kE_{elec} + k\varepsilon_{mp}d^4, & d \geqslant d_0 \end{cases} \tag{2}$$

Where, k is to transmit data bit; d is as the actual communication distance; d_0 is the distance threshold, when the transmission distance is less than d_0, power amplifier loss using a free space model, otherwise the path attenuation model; Eelec represents energy and receiving every bit data sending node circuit; ε FX and ε amp denote respectively the coefficient of energy consumption amplifier in the 2 attenuation mode.

(1) Each node has the same maximum transmit power, its coverage is the radius of circular regions of the R, and by adjusting the transmit power in order to adapt to the communication of different distance nodes within its coverage;

(2) For each node to obtain the residual energy of their own, have certain storage space to store the information of neighbor nodes;

(3) Ignore the obstacle factors such as communication quality exist in the real environment, to ensure that all data packets can be reliable transmission.

The cluster head LEACH protocol is randomly generated, the selection mechanism without considering the residual energy and node has done a number of cluster head. Once the remaining less energy node to become a cluster head will soon run out of energy, premature death. The cluster members will be no dead hair out information and continue to send the request signal, consuming large amounts of energy to accelerate the death, reduces the lifetime of the whole network.

In the cluster building phase, the first node as cluster head randomly determined by base station. The number of cluster heads is determined according to the location, size and the size of network monitoring area. Is selected as the cluster head of ID by the base station are in

the network broadcast, network nodes by comparing successive received ID with their own, the same as the cluster head. After the cluster heads are elected, and then broadcast to the entire network cluster head ID. The cluster node in each round of data transmission at the end of a frame, put together to send information to their residual energy of cluster head. Residual energy of the nodes in the cluster head election, node residual energy is the biggest as the next round of cluster heads, thus established the first layer cluster head.

Then the stable stage of a new round of is data transmission. At this stage, the sensor node will monitor the data to the cluster head, cluster head data fusion with cluster identifier, then transmit the data to the base station, the amount of data the base station statistics for each cluster to send over the. When a data transmission after the end of the round, and it is the base station according to the received every clustering data estimate the energy remaining in the current cluster all nodes.

The sensor node receives the R bit packet energy consumption for:

$$Pr(R) = r\beta \tag{2}$$

Type: β Lu to receive energy coefficient.

$$P_a(r_1+r_2, r) = r(r_1+r_2-r)$$
$$E_{rr}(k,d) = kE_{elec} \tag{3}$$

Where Sensor nodes will be 2 data flow R_1 and R_2 fusion energy dissipation a packet of R, as is shown by Equation (3). Deficiency of the LEACH algorithm in wireless sensor networks, leads to the unbalanced load energy. This paper mainly through the improvement of cluster head election algorithm is to optimize the LEACH protocol. The main goal is to avoid the nodes with low energy as cluster head, cluster head number control to achieve optimal cluster head, reduce uneven distribution in each round of the phenomenon. In order to reduce the energy consumption of the system and it is the final objective to prolong the network life cycle.

The second layer cluster head and the establishment of communication model and LEACH is greatly different from the. Each round of the election of the first layer cluster head becomes the common node second layer cluster head, in LEACH these nodes communicate with the base station directly. By formula (1) can be seen, the amplifier energy consumption is far greater than the circuit energy consumption, energy consumption and communication distance and amplifier in D has a direct relationship, so in the second layer cluster head, fully considering the residual energy of nodes and the node and the base station distance and other factors. The formation of second layer is cluster head threshold calculation according to the following formula.

$$T_{ch} = E_{residual}(i) / BS_{distance}(i) \tag{4}$$

Formula (4): Where $E_{residual}(i)$ is residual energy as cluster heads I identification; $BS_{distance}(i)$ is identified as between cluster head and base station I distance. Each round after the first layer in the cluster heads and cluster head energy higher than a certain value Eth (if the node is lower than Eth that node failure), each cluster head is Tch, find the Tch maximum value is second layer cluster head.

When the interval number of rounds (a long time), or the energy of sensor nodes is lower than a certain value, or a new member nodes are added, the base station and sensor node energy requirements report their own information, and according to the residual energy of the received information to each node to estimate the correction, the numerical the precise division, then re selection and cluster cluster head. Compared with LEACH - C, LEACH - EE protocol does not require sensor nodes to the base station in each round after reporting its position, energy and other information, saving energy costs. At the same time, the interval time of estimation accuracy adjustment, so the performance of LEACH EE protocol is better.

3. Protocol of Time Division Multiplexing MAC

With the development of wireless communication, microelectronics manufacturing technology and sensor technology, wireless sensor networks (WSN) have aroused extensive

attention. WSN is deployed in the monitoring region, a lot of integration is composed of tiny sensor nodes sensing, data processing and wireless communication and power supply module. In intrusion detection, target tracking, environmental monitoring, battlefield surveillance, Bio Medical, emergency rescue and disaster relief and industrial process monitoring applications, the WSN has a wide application prospect.

The positioning mechanism based on distance is through the actual distance or range measured between adjacent nodes to determine the unknown node position, usually ranging, positioning and correcting the steps to achieve. Due to the distance and the angle measured between the nodes positioning mechanism, usually based on distance high positioning accuracy, but the requirements of hardware is also higher. The positioning mechanism distance independent between without actual measurement node distance or angle case can locate the unknown node; this mechanism does not need the actual measurement, the node hardware requirements are reduced, more suitable for large-scale network applications [4]. The positioning mechanism independent of distance from vulnerable to environmental impact and reduce the positioning accuracy, the error will be increased, but enough to satisfy the localization for wireless sensor networks.

The cluster head transmitted continuously 5s synchronization sequence, into low power mode, 5s at the end of the time called the synchronization time point, one of the 10s points, all the sensor nodes in the data in the receiving window are at least able to receive a complete wake-up command. The first complete synchronization command received effective command, according to the sequence number, nodes can decide the location on a time axis, after calculation, get away from the synchronization time of long t. Can see, through continuous synchronous 5s later, all the sensor nodes can be synchronized to the synchronization time point.

The existence of WMSN audio, video information, at the same time, there may be a text information, different parameter concern different applications of different QoS. Therefore, the MAC protocol should be designed according to the different business to provide differentiated services, while achieving efficient use of resources in the network range.

Design of MAC protocols is need a balance between various properties. The performance of the balance between is often more important than individual performance. Because it is not a balanced agreement good performance even in the laboratory, and it is but also may have poor performance in a real environment. For example, a deal if it too often turn off the wireless transceiver saving, not only make the real-time and reliability is affected, packet loss retransmission caused will influence the effect of energy saving.

MAC control messages protocol header includes some control information, such as RTS/CTS/ACK, nodes send the control information need to consume some energy. The wireless communication module, sensor nodes include sending, receiving, state monitoring and dormancy in four states, the current MAC protocol in reducing power consumption mainly concentrated in the add node sleep time, reduce the sensing nodes on the channel.

Even if the synchronization error after 10 min to 24 MS, the N node layer and the N+1 layer node still has a detection window 50-24=26 MS overlap period. If the N layer nodes with two command frame density to the N+1 layer node sends synchronous instruction, still have the opportunity to the bottom node capture one of the command frame, because the 26 ms>22 Ms. The above are the critical time state, if the crystal direction two nodes of the same, it captures the upper synchronization instructions will increase the probability of it.

Real time service is based on CDMA MAC protocol for wireless sensor networks. They think that using CDMA program can provide more bandwidth resources among clusters of flexible configuration, better security and throughput is greater, while allowing for multi domain, airspace joint communication [5]. The equilateral hexagonal cluster structure is with different CDMA coding sequence instead of the multiple frequencies. To send information, each node has 1 transmitting module and a receiving module 6, while in the listener / receiver with 7 receiving module. Compared with TDMA and FDMA mode, CDMA mode reduces internal channel interference, effectively improve the utilization of bandwidth, but the disadvantage is the need of special sensor hardware support, to achieve greater price.

FDMA is the frequency band into a plurality of channels; different nodes can use different channels at the same time. TDMA is a period of time the entire band to a node. Compared with FDMA, TDMA communication time is short, but the overhead of the network time synchronization increases [6]. CDMA is a combination of fixed and random distribution

mode of distribution, with zero channel access delay, bandwidth utilization ratio and statistical multiplexing of good, and can reduce the influence of hidden terminal problem, but the high complexity of channel allocation and base station completely centralized, so that it does not apply to the distribution in WSN.

The channel access probability q is defined in terms of the probability of a time slot was selected as the winner of the node. We assume that the nodes are independent, and the two hop neighbor nodes number of N2 function, and we assume that all nodes have the same two hop neighbor number. When node state is in order to another state and it can consume some energy. The following is the energy consumption state conversion formula (5).

$$P_{st,rx}= P_{rx} \quad P_{tx,rx}=(P_{tx}+ P_{rx})/2 \tag{5}$$

Where $P_{st,rx}$ is the TRAMA protocol, P_{rx} is scheduling access node cycle which is divided into three kinds: transmitting, P_{tx} is receiving and sleep. Send status refers to when and only when the node has data to transmit state, and have the highest priority in the competition; the receiving state is that it is the recipient of the specified node; other nodes in the sleep state. Adaptive slot selection algorithm for AEA is based on the current node priority two hop neighbor nodes within one hop neighbors and scheduling information, decision nodes in the current time slot state strategy: receiving, sending or sleep.

This is a hybrid scheme of a time division multiplexing TDMA and frequency division multiplexing FDMA. In the node maintains a special structure frame, table slot allocation is similar to the TDMA node scheduling, accordingly its communication with the adjacent nodes. Multi channel FDMA technology provides the can at the same time, the communication between multiple nodes, effectively avoids the conflict. Because the channel and time slot allocation of predefined limits the effective use of idle time slot, the business volume is small low channel utilization.

Competitive MAC protocol based on the general use of broadcast channel, the node connected to the channel can be sent to the broadcast channel information. Want to follow certain rules of communication node channel competition, the nodes use right can send information. Competitive MAC protocol including ALOHA and with the carrier sense multiple accesses with collision detection based on the traditional CSMA etc.

4. Construction Protocol of WSN Based on Centralized Clustering Routing and Time Division Multiplexing MAC

In this paper, based on the LEACH protocol, the cluster head directly to reduce the energy loss of base station and remote communication is the primary goal, considering the residual energy of node and the base station at a distance of two layer while selecting the cluster head, and improved the cluster head node multi hop path, avoid the use of low energy. Through the Matlab simulation results show that, the algorithm can further balance the cluster head node energy consumption, prolong the network life cycle.

LEACH algorithm, nodes in the cluster is not transmitted in single hop mode data to the cluster head; it is forwarded through the other nodes in the cluster. Reference proposes a multi hop cluster head model, using the method from bottom to top, layer by layer to generate each layer cluster head, finally get the network WSN a multi-layer structure. The objective function based on the cost of the sensor network design is analyzed with the reference; derive the single hop and multi hop range, finally proposed a routing algorithm for single hop multi hop hybrid, to solve the network of "energy hot" problem.

Mechanism in the LEACH randomly selects a cluster head, did not control the number of cluster head. So it is likely to appear in a round has only one or two cluster head, or have a lot of cluster head case. If the cluster head is too small, then the member nodes to the long path and the cluster head communicate the cluster head will also receive a lot of node information and forwarded to the base station. So to every node would burden; if excessive cluster head, it will have a node and a base station communication much, reduce network energy utilization rate.

The TRAMA protocol through consultation to ensure conflict free distributed nodes send data, to ensure data transmission network has a higher rate at the time of receiving the energy consumption. Compared to the CSMA mechanism of the sensor network MAC protocol based

on TRAMA, realizes data transmission collision probability higher percentage of sleep time and lower the bitmap. In addition, compared to other protocols for multicast and broadcast mode, the communication overhead of TRAMA protocol is also less [7]. But there are some problems: the protocol requires a large storage space to preserve the topology information and the neighbor scheduling information within two hops; for any one time slot is required to calculate the priority and running the AEA algorithm all neighbor nodes within two hops.

Nodes periodically sleep to reduce idle listening energy consumption caused by neighboring nodes; virtual cluster, so sleep scheduling time automatic synchronization; methods using message passing to reduce time delay [8]. S-MAC IEEE 802.11 is still used in similar way to avoid conflict, including virtual and physical carrier sensing and RTS/CTS exchange. Compared with IEEE 802.11, S-MAC has the advantages of energy saving, good characteristic, and the tradeoff between energy and delay under flow conditions. However, each node duty cycle is the same, no node to less energy to give protection. In addition, need further research virtual cluster technique; synchronization schedule can have a big impact on energy consumption.

Wireless sensor network based on clustering structure, based on the TDMA (Energy-awareTDMA) and energy aware mechanism of cluster network MAC protocol. According to the functional differences, cluster network consists of three kinds of nodes: cluster member nodes (also called nodes), the cluster head node and sink node [9]. The node's state is divided into four kinds: induction (Sensing), forwarding (Relaying), induction and forwarding (Sensing and Relaying) and inactive (Inactive) state. Induction state node is responsible for collecting data and transmitted to neighbors. The receiving node sends the other nodes forwarding state data and sends it to the next node. Nodes in sensing and forwarding state need to complete the above two functions.

In the TRAMA protocol, in order to adapt to changes in node failure or node increases the network topology caused by dividing time into alternating, random access cycle and scheduling access cycle. Random access cycle and scheduling access cycle time slot number depending on the specific application. Random access cycle is mainly used for network maintenance, such as the new node is added, the known node failure topology changes to complete in the random access cycle.

This paper uses Matlab to simulate the LEACH - EE protocol, and LEACH, LEACH and C protocols are compared. Simulation scenarios are as follows: 890m × 850m region were deployed 900 sensor nodes, base station is located at coordinates (65, 985), the initial energy of nodes is 854, and the packet size is 453. Node from the total energy distribution, cluster head of network consumption, the network survival number compared LEACH - C and LEACH - EE protocol, and gives the error map different time energy estimates of LEACH - EE protocol, as is shown by Figure 1.
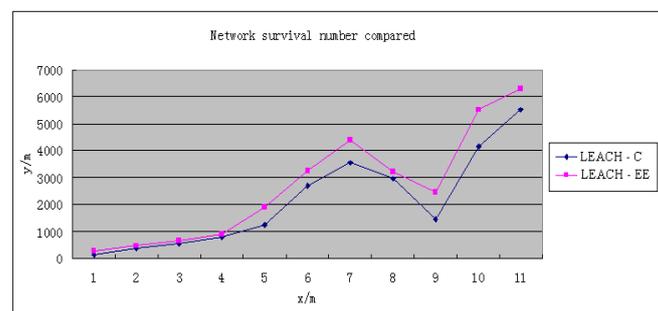

Figure 1. Comparison Results of Compared LEACH - C and LEACH - EE Protocol in WSN

As you can see, the node LEACH EE survival rate is better than LEACH, C and LEACH protocol. The 50 sensor nodes, if you use the LEACH protocol to send data, nodes lasting 403 s network all the death; the use of LEACH - C protocol, is the time for 448 s after all network nodes are dead; and if the LEACH - EE protocol, time until after 502 s in the network nodes they all died.

Modeling the protocols and other processes in the process level is using a finite state machine. For any process was simulated using the C/C++ language in finite state machine state and transition conditions. The user can control the level of detail can meet simulation. Finite state machine with standard C/C++ and OPNET itself provides more than 400 library functions constitute the core Modeler programming. OPNET says this collection for Proto C language.

5. Conclusion

The paper proposes construction protocol of wireless sensor network based on centralized clustering routing and time division multiplexing MAC protocol. In data transmission phase, the common nodes and the first layer of the cluster head communication mode and the same LEACH, but after the data acquisition, fusion is completed not pack data sent directly to the base station, but in a given time slot is sent to the first layer of the respective cluster head. Second layer nodes according to energy and distances to select the next hop node transmit data, the cluster head until the second layer or communicate with the base station directly, the second layer cluster head nodes after two times of data fusion, sending data to the base station.

Design of MAC protocols need a balance between various properties, the properties of equilibrium is often more important than individual performance. Because it is not a balanced agreement good performance even in the laboratory and it is poor performance in a real environment. For example, a deal if it too often turn off the wireless transceiver saving, not only make the real-time and reliability is affected, packet loss retransmission caused will influence the effect of energy saving. Wireless sensor networks for different applications show different properties of networks, MAC layer protocols should be adapted to various flow patterns of different applications.

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